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(54) Title DEVICE FOR MEASURING SPECIFIC ELECTRIC CONDUCTIVITY OF LIQUID MEDIA

(57) Abstract Use: measurement of specific electric conductivity of liquid media under the action of external current sources. Invention essence: a device for measuring specific electric conductivity of liquid media comprises a sensor made in the form of a cup from a solid dielectric material, encased within which cup are a disk-shaped and a ring-shaped electrodes that are connected to a voltage recorder, the disk-shaped electrode being connected to a power supply via a current recorder and a variable resistor connected in series, wherein a technological process power supply is used as the power supply. 1 Figure, 1 Table.

DEVICE FOR MEASURING SPECIFIC ELECTRIC CONDUCTIVITY OF LIQUID MEDIA

DESCRIPTION

The invention relates to measuring equipments, in particular to devices for measuring specific electric conductivity of liquid media under the action of external current sources, including the measurement in local volumes at a low current density.

Known is a sensor comprising a ceramic casing having a channel for lead-outs and a measuring cavity, two current electrodes, three potential probes connected to the measuring cavity. The ceramic casing is bottom-opened. A channel for purging the cavity with an inert gas is arranged between an upper end and the measuring cavity of the ceramic casing [1].

A drawback of this device is in impossibility to measure specific electric conductivities of liquid media under the conditions of a current simultaneously flowing therethrough from an external current source. This is due to that the measurement is performed from an internal current source. When an external current source is present in the measuring cavity, a current will be equal to the sum of two currents: internal one and external one, which brings about great inaccuracies and renders the measurement results unreliable. This makes it impossible to measure specific electric conductivity in an apparatus with a working current continuously flowing through a liquid medium, for example a raw mixture melt in an aluminum production electrolytic cell. In the latter, even a short-term interruption of the working current is impossible in the operating mode. Moreover, the sensor is complicated in structure.

Known is a contact sensor comprising a dielectric tube having three ring-shaped electrodes one of which is arranged on the outside and the two others are mounted in the inside aflush with a tube wall surface, a voltage recorder, an amperemeter, a variable resistor, an internal current source and a switch, wherein the outside electrode and one of the inside electrodes are arranged at the middle of the tube, the inside electrodes are connected to each other via the voltage recorder, the outside and inside electrodes arranged at the middle of the tube are connected via the switch, amperemeter, current source and variable resistor all connected in series [2].

A drawback of this device is the close relationship between a value of current flowing through the measured portion of the medium to be investigated within the sensor, and its spatial orientation with respect to equi-current lines. Since a power current flows through one of the narrow ring-shaped electrodes included into the measuring circuit of the voltage recorder, polarization processes actively takes place at this electrode. Consequently, the measurement accuracy for specific electric conductivity of the medium to be investigated is decreased.

Closest to the inventive device with respect to technical matter is a device for measuring specific electric conductivity, which is made in the form of a dielectric tube with current electrodes and ring-shaped measuring electrodes of which the current electrodes and one of the measuring electrodes are arranged within the tube, comprises an amperemeter and recorders, further comprises a variable resistor connected via the amperemeter to the ungrounded current electrodes made in the form of disks separated from each other by an isolation spacer, wherein the outside electrodes connected to the first recorder are arranged above the inside measuring electrode and the current electrode closest thereto, respectively, which are connected to the second recorder [3].

The device is of special-purpose and, when measuring specific electric conductivities of liquid media at low currents, its accuracy drops as the measured current value becomes commensurable with an inaccuracy of the amperemeter. When a resistance value of the variable resistor is decreased, an intensity of the current flowing through a portion of the medium to be investigated, which portion being arranged within the tube of the sensor, is increased. This increase is possible up to a limit restricted by the total electrical resistance of lead wires and the amperemeter. If an electric field strength at this portion of the medium to be investigated is small, a current intensity value from external current sources becomes then small. The value becomes close to a measuring error for the current intensity by the amperemeter when both the electric field strength and the current density from external current sources are quite low. The device does not permit to substantially affect the measurement accuracy by way of active intervention into the measurement process. For example, at low values of the electric field strength and the current density from the external current sources, an increase in current intensity at the investigated portion of the electrical circuit within the tube of the sensor is possible only by decreasing the resistance value of the variable resistor down to zero. A further increase in current intensity in order to enhance the measurement accuracy for specific electric conductivity of the medium becomes impossible. An essential drawback of this device is obligatory

orientation of the sensor along equi-current lines. This requires special means for orienting the sensor, which leads to raising the cost of this device.

An object of the invention is in providing a device for measuring specific electric conductivity, a structure of which would allow to increase the measurement accuracy for specific electric conductivities of media to be investigated in volumes having minimal current density values from external sources.

An essence of the invention is in that the device for measuring specific electric conductivity, comprising a sensor with a disk-shaped and a ring-shaped electrodes arranged therein, a current recorder and a voltage recorder connected between the disk-shaped and ring-shaped electrodes, a variable resistor, a device for inserting the sensor into a local volume to be investigated, further comprises a cup made of a dielectric material, wherein the disk-shaped electrode is connected to an external power supply via the current recorder and the variable resistor.

The device permits not only to carry out the measurement in a liquid medium under the action thereupon of external current sources, but also to use these sources in the measurement process. By varying a resistance value of the variable resistor, it is possible to affect the measurement accuracy and to obtain good results even at low technological currents from the external current source, i.e. those currents that flow through the liquid medium in an apparatus. This is possible thanks to that, by connecting the current disk-shaped electrode with one of terminals of the power supply, a portion having a much greater resistance than that of the isolation spacer in the known device is excluded from the electrical circuit. In the inventive device, a cross-section of the excluded electrical circuit portion corresponds to an effective cross-section of a bath in the apparatus, over which section the current spreads within the apparatus, and a length of said portion corresponds to a distance from the disk-shaped electrode of the sensor to an electrode of the apparatus, which is connected to one of the terminals of the power supply. This distance can also exceeds a length of the isolation spacer of the closest prior art in many times. When a resistance of the variable resistor is decreased, an electric field strength and a current density at the measured portion of the medium to be investigated are increased. Thus, a current intensity can be increased so much that a measurement error of the current recorder has an unessential effect on the measurement result. A voltage drop between the electrodes will be proportional to a specific electric conductivity of the medium.

Upon immersion into the medium to be investigated, the sensor is filled with a liquid. A volume of the liquid is strictly fixed and depends on geometric dimensions of the sensor. When a current flows from the external current source, a potential difference occurs across the electrodes, which potential difference depends on the specific electric conductivity q of the medium to be investigated and on the geometry of the liquid volume within the sensor. In order to lower the polarization phenomenon, the current electrode is shaped as a solid disk. In order to interrupt a parallel circuit which could close the disk-shaped and ring-shaped electrodes via the medium to be investigated at the external side of the sensor, a base of the cup is made of a dielectric material.

In order to improve the measurement accuracy for q by the device, it is necessary that equi-current lines be parallel when approaching to the ring-shaped electrode. To this end, the electrode is located in the middle of the cup. Due to this, a portion having a non-uniform electrical field is excluded from the measuring circuit. The measurement accuracy for q is not determined by a position of the sensor with respect to the equi-current lines. At any position of the device in the space to be investigated, the intensity of current in the measuring circuit will remain sufficiently high at low values of dropping resistance R.

Thus, a comparison of the claimed solution with other technical solutions shows that the incorporated element is widely known, its incorporation in said connection with other elements of the device, the technological apparatus and the external power supply and their mutual positioning result in occurring the new above-mentioned properties which allow to improve the measurement accuracy for specific electric conductivities of liquid media at low technological currents from the external current source.

This makes it possible to conclude that the claimed technical solution involves an inventive step.

In the drawing, a functional diagram of the device for measuring specific electric conductivity is shown.

The device comprises a specific electric conductivity sensor consisting of a cup 1 made of a dielectric material, a disk-shaped electrode 2 and a ring-shaped electrode 3, and also a voltage recorder 4, a current recorder 5 and a variable resistor 6.

The electrodes 2 and 3 are connected therebetween via the voltage recorder 4. The

disk-shaped electrode 2 via the current recorder 5 and the variable resistor 6 is connected with one of the terminals of the power supply 7.

The cup made of a dielectric material serves to articulate from the medium to be investigated a local space having a limited and precisely known volume. At high working temperatures and in an aggressive medium, the cup can be made of polyvinylchloride, a textolite, a fluoroplastic, and at higher temperatures of materials having a higher melting temperature, for example alundum.

A bottom of the cup is made of the same solid material as walls of the cup. In contrast of the inventive device, the closest prior art device has an isolation spacer made of a dielectric present in one of the aggregative states: solid, liquid, gaseous. In particular, the spacer can be made of air exhibiting a sufficiently high dielectric permittivity. In the inventive device, the cup bottom cannot be liquid or gaseous because in this case the disk-shaped electrode will contact the medium to be investigated at the other side of the cup. In this case, an additional current will flow through the current recorder, which will bring about substantial inaccuracies into the measurement process.

The disk-shaped electrode senses all the working current flowing through the sensor and therefore has a greater area. The polarization is lowered because the current density decreases as the electrode area increases. Small currents flow through the measuring electrode as compared to the current electrode. Here, an effect of the polarization is minimal. The electrodes are made of a material having a high specific electric conductivity and a low susceptibility to surface polarization. At a substantial temperature of the liquid medium to be studied, the electrode material has to exhibit a great high-temperature strength and, in case of increased aggressiveness of the medium, a good corrosion resistance or heat resistance. Both of the electrodes can be made of platinum, stainless steel and, at high temperatures, of zirconium diboride, silicon carbide.

The variable resistor 6 performs the function of dropping resistance and restricts a maximum permissible current I_{gmax} flowing through the disk-shaped electrode of the sensor in a range of 0.05–0.1 A. A nominal resistance value R of the variable resistor is calculated by the formula

$$R = \frac{U_{OC}}{I_{g\,max}} = \frac{U_{OC}}{0.05 - 0.1} = (10 - 20)U_{OC} \quad (1)$$

where U_{OC} is an open circuit voltage of the external power supply of the technological apparatus in which the measurement is carried out, V.

An increase in current intensity above the I_{gmax} results in a substantial activation of the polarization processes at the electrodes and in a decrease in the measurement accuracy (see Iossel Yu. Ya., Electrical fields of constant currents. Leningrad, 'Energoatomizdat' publisher, 1986, p.59, 81).

In order to place the sensor into the medium to be investigated, the device is provided with a steam, for example in the form of a hollow rod (not shown in the drawing), fixed to the middle of the sensor cup. If necessary, the rod is made of heat-resistant and high-temperature materials, and connecting wires are laid within said rod.

The device operates as follows.

The sensor is immersed into the liquid to be investigated through which an electrical current flows, for example, into a slag bath in electroslag remelting, in electroslag hard-facing, in slag welding and so on. An intensity of the current in the measuring circuit is set by the variable resistor so as not to exceed 0.05–0.1 A (if the current intensity increases further, the polarization of disk-shaped electrode raises, the intervention into the technological process enhances, sensors of greater dimensions are required, and a diameter of the lead wires is higher). Then, readings of the current and voltage recorders are noted.

A specific electric conductivity of the medium to be investigated is found out by the formula

$$q = \frac{L}{S} \times \frac{I}{U}, \mathrm{S \cdot m^{-1}} \quad (2)$$

where I is a current intensity according to the reading of the current recorder, A;

U is a voltage according to the reading of the voltage recorder, V;

L is a distance between the electrodes, m;

S is a cross-section area of the disk-shaped electrode, m^2.

K=L/S is a constant and depends on geometrical dimensions of the sensor. Finally,

$$q = K \times \frac{I}{U}, \mathrm{S \cdot m^{-1}} \quad (3).$$

In view of the low currents going through the voltage recorder, the measuring electrode is not practically subjected to the polarization processes. In general, the accuracy performance of the device at I ≅ 0.05–0.1 A is practically independent of the polarization processes.

Metrological performance of the device was obtained during a comparative measurement of a KCl solution of a 0.1N normal concentration

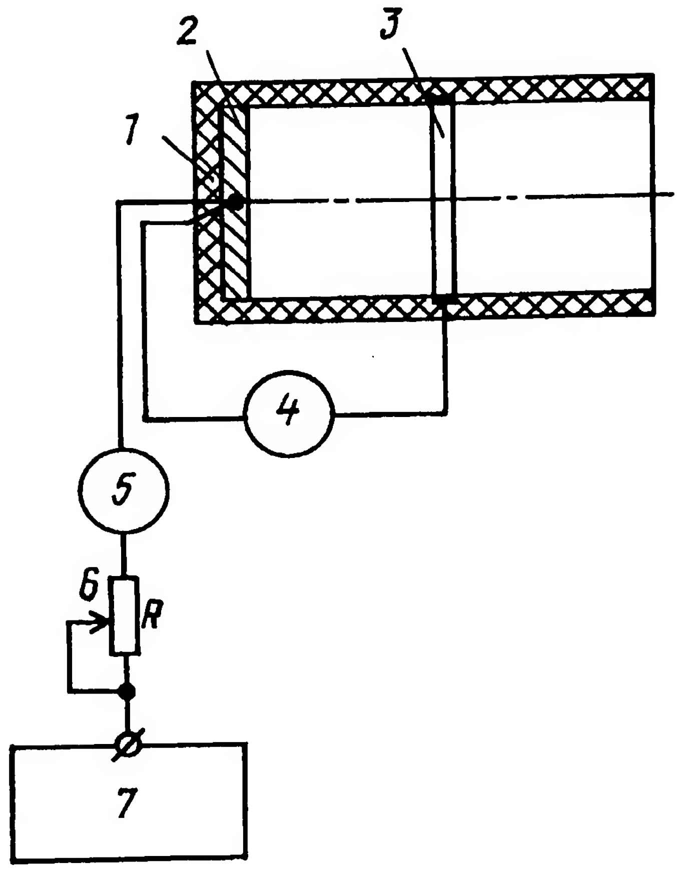
at 20°C. The measurement results are given in the table.

When compared to the closest prior art, the inventive device allows to measure, with a greater accuracy, specific electric conductivities of liquid media at low current densities from external current sources. The device structure is simple. The measurement process is easier than that using the closest prior art device.

CLAIM:

A DEVICE FOR MEASURING SPECIFIC ELECTRIC CONDUCTIVITY OF LIQUID MEDIA, comprising a dielectric tube with a disk-shaped and a ring-shaped electrodes arranged therein, a dielectric spacer arranged near the disk-shaped electrode and forming a cup together with the dielectric tube, a voltage recorder connected between the disk-shaped and ring-shaped electrodes, a current recorder and a variable resistor connected in series to the disk-shaped electrode, characterized in that a cup bottom being the dielectric spacer is made to be solid and of the same dielectric material and of the same thickness as the tube, and a technological process power supply is used as a measurement power supply, a second terminal of the variable resistor being connected to an output of said power supply.

Measurement	Device	R, Ohm	I, A	U, V	L, m	S, m^2	Specific electric conductivity, $S \cdot m^{-1}$		Relative error of measuring for q, %
							q_{actual}	$q_{measured}$	
1	Invention	0	$4.1 \cdot 10^{-4}$	0.0879	$1.2 \cdot 10^{-2}$	$47.76 \cdot 10^{-6}$	1.167	1.172	+0.43
2	Prior art	-	$1 \cdot 10^{-5}$	$1.67 \cdot 10^{-3}$	$1 \cdot 10^{-2}$	$50.24 \cdot 10^{-6}$	1.167	1.191	+2.056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